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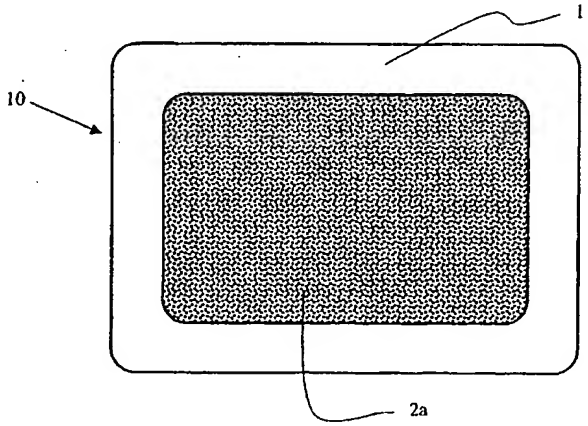
(54) Title: DEVICES AND METHODS FOR TREATING LOW BLOOD SUGAR LEVELS



(57) Abstract: The present invention relates to methods and devices employed to control the onset of blood sugar levels below a predetermined minimum level over an extended period of time. The invention includes methods and devices for producing a therapeutic effect in a subject including placing a source of glucose or glucagon in a transdermal patch in transmitting relationship to an area of intact skin; and administering glucose or glucagon to the subject from the source through the area of intact skin for an extended period of time at a therapeutically effective rate for a substantial portion of the extended period of time to prevent the onset of a low blood sugar level in the subject. The methods and devices may include administering glucose or glucagon to the subject from the source through the area of intact skin for at least 4 hours, or longer, perhaps 24 hours or more, and are particularly well suited for administering glucose or glucagon to the subject from the source through the area of intact skin between usual sleeping hours. Additional therapeutic substances may also be administered to the subject from the source through the area of intact skin, including one or more nutritional supplements such as vitamins A, C, or D.

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DEVICES AND METHODS FOR TREATING LOW BLOOD SUGAR LEVELS

FIELD OF THE INVENTION

The present invention is directed to methods and devices for treating low blood sugar levels in subjects. More particularly, the present invention is directed to various methods and devices for administering glucose or glucagon to a subject through a transdermal patch that the subject wears for an extended period of time.

BACKGROUND OF THE INVENTION

This application claims the benefit of PCT Application No. PCT/US99/20998, filed July 21, 1999, which in turn, claims the benefit of Provisional Application No. 60/088,409, filed July 21, 1998.

In the United States, about 16 million people suffer from diabetes mellitus, although only half of these individuals have been diagnosed. Every year, about 650,000 people learn they have the disease. Diabetes mellitus is the seventh leading cause of all deaths and the sixth leading cause of all disease-caused deaths.

Without an appropriate level of insulin to help absorption, glucose or glucagon levels increase in the blood because glucose or glucagon is not readily absorbed by all other cells in the body. When the blood passes through the kidneys, organs that remove blood impurities, the kidneys cannot absorb the excess glucose. This excess glucose enters into the urine causing frequent urination to get rid of the additional water drawn into the urine. Excessive thirst occurs to trigger replacement of lost water in addition to added hunger to replace the glucose lost in urination. Additional symptoms include blurred vision, dramatic weight loss, irritability, weakness and fatigue, and nausea and vomiting.

Diabetes is classified into two types. Type 1 is known as immune-mediated diabetes (formerly called insulin-dependent diabetes). An estimated 500,000 to 1 million people in the United States have this type of diabetes. Type 1 diabetes destroys the cells in the pancreas that produce insulin, usually leading to a total failure to produce insulin. It typically starts in children or young adults who are slim, but can start at any age. Untreated Type 1 diabetes affects the metabolism of fat. Because the body cannot convert glucose into energy, it begins to break down stored fat for fuel. This produces increasing amounts of acidic compounds called ketone in the blood, which interfere with respiration. People with Type 1 diabetes must give themselves at least one shot of insulin every day. Individuals with Type 1 diabetes measure the level of glucose in a drop of their blood obtained by pricking a fingertip. These measurements are used to adjust the type and amount of insulin individuals must use.

In Type 2 diabetes, or non-insulin-dependent diabetes mellitus, (formerly called adult-onset diabetes), the body either makes insufficient amounts of insulin or is unable to use it. Type 2 diabetes often develops slowly. Most people who get it have increased thirst and an increased need to urinate. Many also feel edgy, tired and sick to their stomach. Some people have an increased appetite, but they lose weight. Other signs include repeated or hard-to-heal infections of the skin, gums, vagina or bladder; blurred vision; tingling or loss of feeling in the hands or feet; and dry, itchy skin.

Type 2 diabetes accounts for 90 to 95 percent of all cases of diagnosed diabetes in the United States. Each year nearly 600,000 new cases are diagnosed. The onset of Type 2 diabetes usually occurs after the age of 40 and often after the age of 55. Type 2 diabetes is known to cause problems with the kidneys, legs and feet, eyes, heart, nerves and blood flow.

If left untreated, Type 1 diabetes can result in diabetic coma (a state of unconsciousness caused by extremely high levels of glucose in the blood) or death. In both Type 1 and Type 2 diabetes, blood sugar, blood pressure, and blood fats must be

well-controlled to prevent possible development of blindness, kidney failure, and heart disease. Also, tiny blood vessels in the body may become blocked-a dangerous complication. When blood vessels of the eye are affected, it can result in retinopathy, the breakdown of the lining at the back of the eye. When the kidney is affected it is called nephropathy, the inability of the kidney to properly filter body toxins.

According to the American Diabetes Association, the total annual economic cost of diabetes in 1997 was estimated to be $98 billion dollars. That includes $44.1 billion in direct medical and treatment costs and $54 billion for indirect costs attributed to disability and mortality. In 1997, total health expenditures incurred by people with diabetes amounted to $77.7 billion. including health care costs not resulting from diabetes. The per capita costs of health care for people with diabetes amounted to $10,071 while health care costs for people without diabetes amounted to $2,699 in 1997.

In an effort to provide a natural source of insulin, some patients have received pancreas transplants. These patients must receive immunosupressant therapies to prevent their body from rejecting the new pancreas. However, the side effects of these pharmaceuticals are often more life-threatening than the diabetic condition itself.

While the use of insulin is extremely important in controlling glucose levels in diabetic patients, there are undesirable effects associated with this treatment. Patients with diabetes who use insulin are at risk for hypoglycemia. If these patients follow the guidelines set forth by the Diabetes Control and Complications Trial (DCCT) or an intensive management program, they may encounter problems in matching diet to the insulin regimen. These patients are several times more likely to experience hypoglycemia as those who do not follow the guidelines. Patients following an intensive management program may combat hypoglycemia more effectively if they understand how different foods affect blood glucose.

Some type-one diabetics have large swings in blood sugar levels as a result of insulin treatment. Normal blood sugar levels in humans range from between 80 and 140

mg/dL. In some cases, blood sugar levels can drop to fatal levels, i.e. levels below 30 to 40 mg/dL, depending on the subject.

Hypoglycemia, a particularly harmful form of low blood sugar levels, impacts the brain or nerve center, which derives almost all its energy from glucose. The brain depends on the blood stream for a continuous supply of glucose because it can only store a few minutes worth of energy as glycogen, a precursor to glucose. Any change in blood glucose levels can quickly and seriously affect thinking and coordination.

The body has a number of backup systems for raising low blood sugars. A research paper done by Dr. Phillip Cryer at Washington University School of Medicine, outlined these recovery systems. The first response, which occurs at around 83 mg/dL, is a reduction of insulin production. The second response, the release of epinephrine into the bloodstream, begins at 69 mg/dL, but plays a minor role unless the supply of glucagon, a hormone produced by the pancreas that causes release of glycogen from the liver, becomes deficient. Glucagon release begins at 68 mg/dL, followed at 67 mg/dL by a reduced glucose uptake into the brain. At 66 mg/dL, the body releases the growth hormone somatropin, which inhibits the use of glucose. As the blood glucose level reaches 58 mg/dL, cortisol, a steroid that promotes the conversion of glycogen into glucose, is released to assist the growth hormone somatotropin. Only when the glucose level falls to 54 mg/dL do hypoglycemic symptoms occur. At 49mg/dL thinking becomes impaired.

Some people with diabetes experience symptoms at higher glucose levels. Others appear to function well with blood sugars in the 30s and 40s. Therefore, the values in Dr. Cryer's study should only be used as an approximation.

Two types of symptoms are associated with hypoglycemia. The first set of symptoms are neurogenic (body) symptoms, which originate in the nervous system, affect the body, and are usually noticed by the person with diabetes himself. The second set of symptoms are neuroglycopenic (mind) symptoms, which affect the mind. The latter are a

direct result of glucose deprivation in the brain, and are frequently noticed by others but not by the person with diabetes. In the controlled study of nondiabetics, the neurogenic systems occur at around 54 mg/dL and include shaking, pounding heart, nervousness, sweating, tingling and hunger. Neuroglycopenic symptoms, which occur at 49 mg/dL, are confusion, drowsiness, weakness, feeling too warm, difficulty speaking, impaired coordination and odd behavior.

The conventional risk factors causing hypoglycemia include excessive insulin in the blood (due to either high dosage or missed meals); an increase in the use of insulin (as seen during exercise); a decrease in glucose production (as occurs after drinking alcohol), or an increase in insulin sensitivity (also seen during exercise).

Additional risk factors are related to therapy and control and include a history of severe hypoglycemia, having type 1 diabetes for over nine years to 12 years, any lowering of HbA1c levels and an increase in your insulin dose. Any hypoglycemic event can impair the body's detection of future hypoglycemia for up to three days. This means glucose levels must go even lower to produce hypoglycemic symptoms and activate glucose counterresponse.

Hypoglycemia unawareness, the clinical condition in which people no longer experience the neurogenic symptoms of low blood sugars, affects many people with type 1 diabetes and a few with type 2. The glucose levels needed to trigger glucose counterresponse are lower in people with hypoglycemia unawareness and the first symptom they usually experience is neuroglycopenia, a sign of blood sugars of 49 mg/dL or less. Recent studies indicate that avoiding hypoglycemia for a period of time as short as a few weeks may reverse hypoglycemia unawareness.

Although hypoglycemia can occur at any time during the day or night, it is particularly troublesome at night. Nocturnal hypoglycemia is often fatal because the subject is unaware of their blood sugar level. Hypoglycemia is also problematic when insulin dependent diabetics are required to fast in preparation for medical tests or

procedures due to reduced food intake. As such, a treatment to prevent or combat the effects of hypoglycemia, especially nocturnal hypoglycemia is of great importance.

Traditionally, low blood sugar levels and hypoglycemia have been treated in many different manners. Control of one's diet is an effective way to prevent or treat low blood sugar. Another method of treating hypoglycemia is by ingestion of some form of sugar tablet or other composition. However, these forms of treatment are only effective after the determination of low blood sugar levels. With diabetic treatments, especially those using insulin, blood sugar levels are frequently monitored. When the blood sugar level reaches a particular point, the above-described treatments may be undertaken.

It is difficult to monitor blood sugar levels during the normal sleeping hours of a patient, e.g. from midnight to morning. In addition, certain requirements for fasting, such as in preparation for medical procedures, require a patient to go without food for long periods of time, making sugar ingestion impractical or impossible.

Therefore, it is an object of the present invention to provide methods and devices for a subject to use during these times of increased chance of hypoglycemic or low blood sugar level conditions, to prevent the onset of such conditions.

SUMMARY OF THE INVENTION

The present invention relates to methods and devices employed to control the onset of blood sugar levels below a predetermined minimum level over an extended period of time. More particularly, the present invention is directed to methods and devices that deliver a form of glucose in a time released manner through the epidermis over an extended period of time.

One aspect of the present invention is directed to a method of producing a therapeutic effect in a subject by placing a source of glucose in a transdermal patch in a transmitting relationship to an area of intact skin; and administering glucose or glucagon

to the subject from the source through the area of intact skin for an extended period of time at a therapeutically effective rate for a substantial portion of the extended period of time to prevent the onset of a low blood sugar level in the subject.

This method may include administering glucose or glucagon or glucagon to the subject from the source through the area of intact skin for at least 4 hours, or longer, perhaps 24 hours or more. The method may also include administering glucose or glucagon or glucagon to the subject from the source through the area of intact skin between certain specific time frames, for example during sleeping hours of a subject. The method may also include administering glucose or glucagon to the subject from the source through the area of intact skin at a rate to maintain the blood sugar level of the subject at a predetermined level, such as at or above 40mg/dL.

In addition to administering glucose or glucagon the method also contemplates administering contemporaneously an additional therapeutic substance to the subject from the source through the area of intact skin. The additional therapeutic substance can be one or more nutritional supplements such as vitamins A, C, or D.

According to another aspect of the present invention, a medical device for transdermal administration of glucose or glucagon is contemplated. The device is adapted to deliver glucose or glucagon at an antihypoglycemic effective rate during a substantial portion of a predetermined administration period. The device comprises a glucose or glucagon reservoir comprising a glucose or glucagon medium wherein glucose or glucagon comprises a majority concentration of the medium. A glucose or glucagon release rate control structure is disposed in the path of glucose or glucagon migration from the reservoir to the skin, the release rate structure being permeable to glucose or glucagon and substantially impermeable to material other than glucose or glucagon. An adhesive is disposed adjacent to the path of glucose or glucagon migration from the release rate structure to the skin.

Preferably, the device according to this aspect of the invention has a glucose or glucagon release rate control structure that is adapted to provide a controlled release of glucose or glucagon over at least a 4 hour period, and also potentially over a 24 hour period or longer. The glucose or glucagon release rate control structure may be adapted to provide a controlled release of glucose or glucagon between normal sleeping hours. The glucose or glucagon release rate control structure is preferably adapted to provide a controlled release of glucose or glucagon at a rate to maintain the blood sugar level at a predetermined level, for example at or above 40mg/dL.

According to this aspect of the invention, the glucose or glucagon release rate control structure may further be adapted to provide a controlled release of glucose or glucagon and an additional therapeutic substance from the source through the area of intact skin. The additional therapeutic substance is one or more nutritional supplements, including, for example one or more of vitamins A, C, or D.

According to another aspect of the invention, a method is contemplated for treating low blood sugar levels in a subject, comprising; placing a transdermal patch containing a substance consisting essentially of glucose or glucagon or glucagon in contact with an area of intact skin; and administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time at a therapeutically effective rate to prevent the onset of a blood sugar level in the subject below a predetermined level, for example 40mg/dL.

According to another aspect of the invention, a device is contemplated for treating low blood sugar levels in a subject. The device comprises a transdermal patch further comprising a reservoir section formed between a fluid impermeable layer and a migration regulating layer. An adhesive layer is also provided and is positioned on a surface of the patch so as to be in contact with a skin surface of the subject, thereby holding the patch in position. A solution consisting essentially of glucose or glucagon contained within the reservoir, the solution being of a concentration and amount sufficient to prevent the blood

sugar level in the subject from falling below a certain level, for instance, about 40mg/dL. According to this aspect of the invention, the solution preferably comprises a sufficient concentration of glucose or glucagon to prevent the onset of hypoglycemia.

According to another aspect of the invention, a method for preventing the onset of hypoglycemia is contemplated. This method comprises placing a transdermal patch containing a substance consisting essentially of a composition for preventing the onset of hypoglycemia in contact with an area of intact skin; and administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time at a therapeutically effective rate to prevent the onset of hypoglycemia.

Another contemplated aspect of the present invention is a method of preventing the onset of nocturnal hypoglycemia in a subject, comprising placing a transdermal patch containing a substance consisting essentially of a composition for preventing the onset of hypoglycemia in contact with an area of intact skin; and administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time overnight at a therapeutically effective rate to prevent the a blood sugar level in the subject from dropping below a certain level, for example, 40mg/dL.

According to a further aspect of the invention, a device for treating low blood sugar levels in a subject is contemplated, the device, comprising a patch having a reservoir section formed between a fluid impermeable layer and a migration regulating layer, and an adhesive layer positioned on a surface of the patch so as to be in contact with a skin surface of the subject, thereby holding the patch in position. The device further comprises a solution comprising a composition for preventing the onset of hypoglycemia contained within the reservoir, the solution being of a concentration and amount sufficient to prevent the onset of a hypoglycemic condition in the subject.

According to another aspect of the invention, a transdermal patch for treating low blood sugar level conditions in a subject is provided, comprising a fluid impermeable layer; a fluid migration regulating layer; a reservoir located between the fluid

impermeable layer and the fluid migration regulating layer; and an adhesive layer formed on a surface of the patch so as to be in contact with a skin surface of the subject. A solution comprised substantially of a composition to maintain a blood sugar level at a predetermined minimum level contained within the reservoir, the composition has a concentration sufficient to prevent the onset of a hypoglycemic condition in the subject for an extended period of time when the patch is worn by the subject.

A further aspect of the present invention is directed to a method for treating low blood sugar level conditions in a subject, comprising forming a transdermal patch having a fluid impermeable layer, a fluid migration regulating layer; and an adhesive layer formed around a perimeter of the transdermal patch; filling the transdermal patch with a solution comprised substantially of a composition for maintaining a blood sugar level at a predetermined minimum level; adhering the transdermal patch to an intact skin section of the subject; and migrating the solution from the reservoir through the fluid migration regulating layer and the intact skin in a regulated manner to prevent a blood sugar level lower than the predetermine level in the subject over a predetermined period of time.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention will become more clearly understood it will be disclosed in greater detail with reference to the accompanying drawings, in which:

Figure 1 illustrates a top view of a transdermal patch for delivering glucose or glucagon according to the present invention.

Figure 2 is a side view of the transdermal patch of Figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With the rapid improvements in the treatment of medical conditions using transdermal delivery systems, patch technology offers a new way to combat the effects of

hypoglycemia, in particular, and to treat low blood sugar levels for prolonged periods of time, such as overnight.

Referring now to Fig. 1, a transdermal patch in accordance with the present invention is generally shown at 10. As illustrated, the patch 10 includes a solution reservoir area 11 within a perimeter 12 that defines the outer dimensions of the patch 10.

As shown in Fig. 2, the transdermal patch 10 is preferably used for treating low blood sugar level conditions in a subject. The patch includes a fluid impermeable layer 1 and a fluid migration regulating layer 3. A reservoir 2 is located between the fluid impermeable layer 1 and the fluid migration regulating layer 3. An adhesive layer 4 is formed on a perimeter surface of the patch so as to be in contact with a skin surface of the subject. The adhesive layer may include an active ingredient as well as the adhesive.

A solution 2a comprised substantially of a composition to maintain a blood sugar level at a predetermined minimum level contained within the reservoir. The composition preferably has a concentration sufficient to prevent the onset of a hypoglycemic condition in the subject for an extended period of time when the patch is worn by the subject. The solution may be in the form of a saturated hydrophilic gel and may or may not include penetration enhancers. Various forms of penetration enhancers are known in the patch art and could be readily used according to the present invention if desired.

The preferred active ingredient in the solution is a substantially pure form of glucose or glucagon. Other forms of therapeutic compositions may be substituted for glucose or glucagon and still be within the contemplated invention. The important feature herein lies not in the particular composition, but in the deliverable concentration thereof to be therapeutically effective. A substantially pure form of glucose or glucagon is a concentration primarily comprising glucose or some other glucagon composition, at a level that can therapeutically treat a blood sugar level, such as a level below 70 mg/dL.

In operation, when patch 10 is placed on a skin area of a user, solution 2a migrates from reservoir 2 through delivery membrane 3, onto the skin of the user where it is

absorbed through the skin and into the blood stream. The rate of delivery of solution 2a can be controlled by varying the porosity of the membrane layer 3 or by varying the viscosity of the solution 2a, or by a combination thereof.

The fluid impermeable layer 1 may comprise, for example, an occlusive foil backing, and the fluid migrating layer preferably includes a micorporous delivery membrane. The composition in solution 2a preferably includes a solution consisting essentially of glucose or glucagon contained within the reservoir, the solution being of a concentration and amount sufficient to prevent the blood sugar level in the subject from falling below a certain level, for example about 40mg/dL. The fluid migrating layer 3 may further be adapted to provide a controlled release of glucose or glucagon, and an additional therapeutic substance from the source through the area of intact skin. The additional therapeutic substance is one or more nutritional supplements, including, for example one or more of vitamins A, C, or D.

According to one aspect of the invention, a method of producing a therapeutic effect in a subject is provided. This method comprises placing a source of glucose or glucagon in a transdermal patch in transmitting relationship to an area of intact skin. The glucose or glucagon is then administered to the subject from the source through the area of intact skin for an extended period of time at a therapeutically effective rate for a substantial portion of the extended period of time to prevent the onset of a low blood sugar level in the subject.

This method may include administering glucose or glucagon to the subject from the source through the area of intact skin for at least 4 hours, or longer, perhaps 24 hours or more. The method also contemplates administering glucose or glucagon to the subject from the source through the area of intact skin between a user's normal sleeping hours.

In addition to administering glucose or glucagon, additional therapeutic substances can be administered contemporaneously to the subject from the source through the area of intact skin. The additional therapeutic substance can be one or more

nutritional supplements such as vitamins A, C, or D. Preferably, glucose or glucagon is administered to the subject from the source through the area of intact skin at a rate to maintain the blood sugar level of the subject at or above 40mg/dL.

According to another aspect of the invention, a method is contemplated for treating low blood sugar levels in a subject, comprising: placing a transdermal patch containing a substance consisting essentially of glucose or glucagon or glucagon in contact with an area of intact skin; and administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time at a therapeutically effective rate to prevent the onset of a blood sugar level in the subject below a predetermined level, such as 40mg/dL.

According to the invention, the onset of hypoglycemia is prevented over an extended period of time by placing a transdermal patch containing a substance consisting essentially of a composition for preventing the onset of hypoglycemia in contact with an area of intact skin; and administering the substance to the subject from the transdermal patch through the area of intact skin. This is also an effective way to treat and/or prevent the onset of nocturnal hypoglycemia in a subject.

The above detailed description of a preferred embodiment of the invention sets forth the best mode contemplated by the inventor for carrying out the invention at the time of filing this application and is provided by way of example and not as a limitation. Accordingly, various modifications and variations obvious to a person of ordinary skill in the art to which it pertains are deemed to lie within the scope and spirit of the invention as set forth in the following claims.

CLAIMS

What is claimed is:

1. A method of producing a therapeutic effect in a subject, comprising:

placing a source of glucose or glucagon in a transdermal patch in transmitting relationship to an area of intact skin; and

administering glucose or glucagon to the subject from the source through the area of intact skin for an extended period of time at a therapeutically effective rate for a substantial portion of said extended period of time to prevent the onset of a low blood sugar level in the subject.

2. The method of claim 1, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin for at least 24 hours.

3. The method of claim 1, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin while the subject is sleeping.

4. The method of claim 1, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin for at least 4 hours.

5. The method of claim 1, further comprising administering glucose or glucagon and an additional therapeutic substance to the subject from the source through the area of intact skin.

6. The method of claim 5, wherein the additional therapeutic substance is one or more nutritional supplements.

7. The method of claim 6. wherein the one or more nutritional supplements comprises one or more of vitamins A, C, or D.

8. The method of claim 1, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin at a rate to maintain the blood sugar level of the subject at or above a predetermined level.

9. A medical device for transdermal administration of glucose or glucagon, the device being adapted to deliver glucose or glucagon at an antihypoglycemic effective rate during a substantial portion of a predetermined administration period comprising, in combination:

a. a glucose or glucagon reservoir comprising a glucose or glucagon medium wherein glucose or glucagon comprises a majority concentration of the medium;

b. a glucose or glucagon release rate control structure disposed in the path of glucose or glucagon migration from the reservoir to the skin, the release rate structure being permeable to glucose or glucagon and substantially impermeable to material other than glucose or glucagon; and

c. an adhesive disposed adjacent to the path of glucose or glucagon migration from the release rate structure to the skin.

10. The medical device according to claim 9, wherein the glucose or glucagon release rate control structure is adapted to provide a controlled release of glucose or glucagon over at least a 24 hour period.

11. The medical device according to claim 9, wherein the glucose or glucagon release rate control structure is adapted to provide a controlled release of glucose or glucagon between a predetermined time period.

12. The medical device according to claim 9, wherein the glucose or glucagon release rate control structure is adapted to provide a controlled release of glucose or glucagon for at least 4 hours.

13. The medical device according to claim 9, wherein the glucose or glucagon release rate control structure is adapted to provide a controlled release of glucose or glucagon and an additional therapeutic substance from the source through the area of intact skin.

14. The medical device according to claim 13, wherein the additional therapeutic substance is one or more nutritional supplements.

15. The medical device according to claim 14, wherein the one or more nutritional supplements comprise one or more of vitamins A, C, or D.

16. The medical device according to claim 9, wherein the glucose or glucagon release rate control structure is adapted to provide a controlled release of glucose or glucagon at a rate to maintain the blood sugar level at or above 40mg/dL.

17. A method of treating low blood sugar levels in a subject, comprising:

placing a transdermal patch containing a substance consisting essentially of glucose or glucagon in contact with an area of intact skin; and

administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time at a therapeutically effective rate to prevent the onset of a blood sugar level in the subject below a predetermined level in the subject based on physical characteristics of the subject.

18. The method of claim 17, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin for at least 24 hours.

19. The method of claim 17, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin while the subject is sleeping.

20. The method of claim 17, further comprising administering glucose or glucagon to the subject from the source through the area of intact skin for at least 4 hours.

21. The method of claim 17, further comprising administering the substance and an additional therapeutic substance to the subject from the source through the area of intact skin.

22. The method of claim 21, wherein the additional therapeutic substance comprises a nutritional supplement.

23. The method of claim 22, wherein the one or more nutritional supplements comprises one or more of vitamins A, C, or D.

24. A device for treating low blood sugar levels in a subject, comprising:

a transdermal patch further comprising a reservoir section formed between a fluid impermeable layer and a migration regulating layer; and an adhesive layer positioned on a surface of the patch so as to be in contact with a skin surface of the subject, thereby holding the patch in position; and

a solution consisting essentially of glucose or glucagon contained within the reservoir, the solution being of a concentration and amount sufficient to prevent the blood sugar level in the subject from falling below a predetermined level.

25. The device according to claim 24, wherein the migration regulating layer provides a controlled release of the solution over at least a 24 hour period.

26. The device according to claim 24, wherein the migration regulating layer provides a controlled release of the solution between a predetermined period of time.

27. The device according to claim 24, wherein the migration regulating layer provides a controlled release of the solution for at least 4 hours.

28. The device according to claim 24, wherein migration regulating layer provides a controlled release of the solution and an additional therapeutic substance from the source through the area of intact skin.

29. The device according to claim 28, wherein the additional therapeutic substance comprises a nutritional supplement.

30. The method of claim 29, wherein the one or more nutritional supplements comprises one or more of vitamins A, C, or D.

31. The device according to claim 24, wherein the solution comprises a sufficient concentration of glucose or glucagon to prevent the onset of hypoglycemia.

32. A method of preventing the onset of hypoglycemia, comprising:

placing a transdermal patch containing a substance consisting essentially of a composition for preventing the onset of hypoglycemia in contact with an area of intact skin; and

administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time at a therapeutically effective rate to prevent the onset of hypoglycemia.

33. A method of preventing the onset of nocturnal hypoglycemia in a subject, comprising:

placing a transdermal patch containing a substance consisting essentially of a composition for preventing the onset of hypoglycemia in contact with an area of intact skin; and

administering the substance to the subject from the transdermal patch through the area of intact skin for an extended period of time overnight at a therapeutically effective rate to prevent the a blood sugar level in the subject from dropping 40mg/dL.

34. A device for treating low blood sugar levels in a subject, comprising:

a patch having a reservoir section formed between a fluid impermeable layer and a migration regulating layer, and an adhesive layer positioned on a surface of the patch so as to be in contact with a skin surface of the subject, thereby holding the patch in position; and

a solution comprising a composition for preventing the onset of hypoglycemia contained within the reservoir, the solution being of a concentration and amount sufficient to prevent the onset of a hypoglycemic condition in the subject.

35. A transdermal patch for treating low blood sugar level conditions in a subject, comprising:

a fluid impermeable layer;

a fluid migration regulating layer;

a reservoir located between the fluid impermeable layer and the fluid migration regulating layer;

an adhesive layer formed on a surface of the patch so as to be in contact with a skin surface of the subject; and

a solution comprised substantially of a composition to maintain a blood sugar level at a predetermined minimum level contained within the reservoir, the composition having a concentration sufficient to prevent the onset of a hypoglycemic condition in the subject for an extended period of time when the patch is worn by the subject.

36. A method for treating low blood sugar level conditions in a subject, comprising:

forming a transdermal patch having a fluid impermeable layer, a fluid migration regulating layer; and an adhesive layer formed around a perimeter of the transdermal patch;

filling the transdermal patch with a solution comprised substantially of a composition for maintaining a blood sugar level at a predetermined minimum level;

adhering the transdermal patch to an intact skin section of the subject; and

migrating the solution from the reservoir through the fluid migration regulating layer and the intact skin in a regulated manner to prevent a blood sugar level lower than the predetermine level in the subject over a predetermined period of time.

FIG. 1

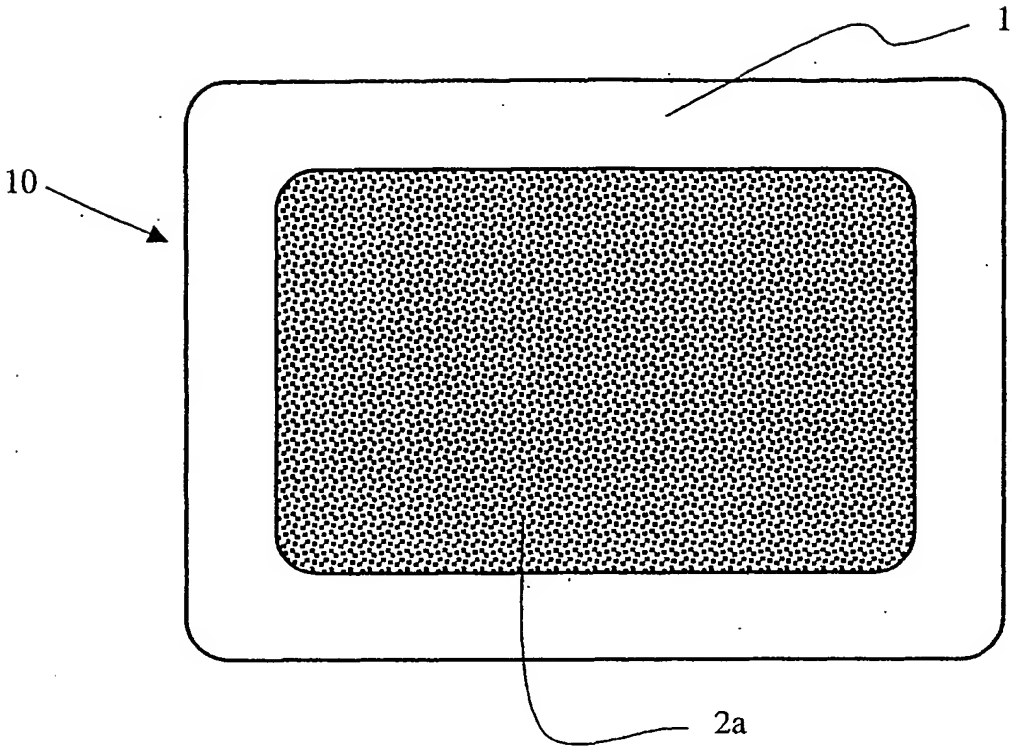

FIG. 2